Test Procedure for

STANDARDIZATION AND CALIBRATION OF WEIGHING DEVICES USED FOR LABORATORY TESTING

TxDOT Designation: Tex-901-K

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1. SCOPE

1.1 This test procedure covers the standardization and calibration of weighing devices and includes testing the accuracy, eccentric loading, and repeatability of the balance.

1.2 Part 1 of this procedure applies to standardizing general-purpose scales and balances. The accuracy requirements for balances and scales are specified in terms of the combined effect of all sources of error contributing to overall balance performance.

1.3 Part 2 of this procedure applies to the calibration of non-automatic weighing instruments.

1.4 Weighing instruments have capacities from a few grams up to several thousand kilograms, with a scale interval typically from 0.1 µg up to 1 kg. Note that non-automatic weighing instruments are usually referred to as either balances or scales. In this practice, for brevity, non-automatic weighing instruments will be referred to as balances; however, the scope of this practice also includes scales.

1.5 The values stated in SI units are to be regarded as standards. The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

1.6 This Standard does not purport to address all safety concerns, if any, associated with its use. It is the responsibility of the user of this Standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations before use.

2. REFERENCE DOCUMENTS

2.1 AASHTO M-231, Weighing Devices used in the Testing of Materials.

2.2 ASTM D4753, Standard Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing.

2.3 ASTM E898, Standard Practice for Calibration of Non-Automatic Weighing Instruments.

2.4 ASTM E617, Standard Specification for Laboratory Weights and Precision Mass Standards.

3. TERMINOLOGY

3.1 Acceptance tolerance—the maximum permissible deviation from the correct indication for new standard masses or balances and for standard masses or balances having received major servicing. Usually equal to one half of the maintenance tolerance.

3.2 Accuracy—maximum permissible deviation of indications of a balance or scale from the true value within applicable tolerances.

3.3 Balance—an instrument for determining the mass of an object by the action of gravity on the object. See scale.

3.4 Basic condition—a condition that must be met before a basic measurement for evaluating a balance can be performed.

3.5 Basic measurement (of error)—evaluating a balance by determining the change of indication of the balance when a known mass is added to or subtracted from any mass already on the balance and the difference between the change in the indication determined and the known value of the mass.

3.6 Basic tolerance—tolerances that are established by a particular code for a particular device under all normal tests, whether maintenance or acceptance.

3.7 Capacity of a balance—the maximum mass recommended by the manufacturer, disregarding any additional capability supplied by a taring device.

3.8 Direct-reading balance—a balance on which the mass of applied loads of various magnitudes is either automatically indicated, or is indicated by means of a calibrated weighbeam, throughout all or portion of the range of the balance.

3.9 Eccentric loading—application of a load to the pan of a balance at a point displaced from the center of the support axis of the load-receiving element.

3.10 Equal-arm balance—a balance having a beam supported exactly in the middle, having two pans suspended from its extremities, in which the mass of the unknown quantity on one pan is compared with a set of standards of mass in the other pan. There may or may not be a weighbeam.

3.11 General-purpose balance—any balance used to make a laboratory, industrial, education, and home use determination of mass.

3.12 General-purpose determination of mass— a single determination of mass using a balance (not a special purpose determination of mass involving repeat determinations of mass, averages, standard deviations, corrections, etc.).

3.13 General-purpose standard mass—a standard mass used with a balance to make a general-purpose determination of mass. See general-purpose determination of mass.

3.14 Hysteresis—the difference between successive measurements of a standard mass when the standard mass is measured after a cycle of adding, and then removing (or removing, then adding) mass from the balance.

3.15 Linearity error—in balances, this expression is applied to the plus or minus deviation from the theoretically straight-lined (linear) course of two interdependent values of the indicated measurement value from the true (actual) value of the mass.

3.16 Maintenance tolerance— maximum permissible deviation from the correct indication for masses or balances.

3.17 Nongraduated balance—balances not fitted with a scale numbered in units of mass.

3.18 Off-center error—of a top loading or platform balance, the difference in indicated value when a mass is shifted to various positions on the loading area (pan or platform); eccentric load error.

3.19 Off-center loading—see eccentric loading.

3.20 Precision of a balance—the degree of agreement between the indications of a balance for repeated determinations of the same mass under essentially the same conditions.

3.21 **Readability**. Type I—the value of the smallest unit of mass that can be read without estimation over the given range of measurement either directly or by use of a vernier or micrometer. Type II—the value of the smallest unit of mass that can be read with estimation over the given range of measurement. Type III—the value of the smallest unit of mass that can be read when in-service conditions such as draft, vibration, and other environmental conditions affect the balance while the balance is in use, but not smaller than readability Type I.

3.22 Reproducibility—see precision of a balance.

3.23 Scale—see balance.

3.24 Sensitivity—(1) the ratio of the deflection (ΔL) of the balance indicator or self-indicating display to the mass (ΔM) causing the deflection; S = ΔL/ΔM at a given mass. (2) Mass required to produce a discernible movement in the indicating system of the balance.

3.25 Standard mass—an object of specified mass and construction used with balances, and for the verification of balances and other masses.

3.26 Standard analytical masses—working standards of mass used for analytical work, having relatively small tolerances from the nominal value.

3.27 Standardization—a process that determines (1) the correction to be applied to the result of a measuring instrument, measuring system, material measure, or measurement standard when its values are compared with the values realized by standards, or (2) the adjustment to be applied to a piece of equipment when its performance is compared with that of an accepted standard or process. A simplified form of calibration that estimates systematic error but does not identify random error. Standardization, therefore, does not address all the elements of uncertainty of measurement and does not lead to traceable measurements.

3.28 Tolerance—a value fixing the limit of allowable error or departure from true performance or value.

4. CLASSIFICATION

4.1 Balances are divided into classes based on readability. Analytical balances are divided into two classes designated A and B (See Table 1). General-purpose balances are divided into five classes designated G1, G2, G5, G20, and G100. (See Table 2). ASTM designation is GP.

4.2 Standard masses are classified in accordance with ASTM E617 and the correct class of mass is required to calibrate balances.

4.3 General purpose standard masses tolerances are listed in AASHTO 231 and should be used to perform a standardization of general-purpose balances.

5. APPARATUS

5.1 Analytical Balances—Conforming to the requirements in Table 1.

5.2 Analytical Masses— Conforming to the tolerance in ASTM E617 are used for the calibration of balances.

5.3 General-purpose Balance— Conforming to the requirements in Table 2.

5.4 General-Purpose Masses— Conforming to the tolerances of Table 3 are to be used for the standardization of general balances.

PART I – STANDARDIZATION OF BALANCES

6. PROCEDURE

6.1 PREPARATION BEFORE STANDARDIZATION

6.1.1 This procedure must be performed at the location of use of the balance. If the balance is moved to another location during or after performing this procedure, the procedure will have to be reperformed from the beginning.

6.1.2 Ensure there is a label on each balance stating the class of the balance in a location easily seen by the user. Annotate the balances applicable information and select the class on the standardization certificate.

6.1.3 The balance should be energized before performing this procedure by the time specified by the manufacture. If there is no such rule, the balance warm-up time should be no less than 30 min.

6.1.4 If the balance is equipped with an auto-zero function, this function should be turned off, if possible.

6.1.5 Clean the platform or pan, beams, display, etc. as needed. On laboratory balances, be sure that no debris or portion of a plastic cover restricts pan movement.

6.1.6 Ensure the balance is level. If the balance does not have an internal level or it is inoperable, an external level may be used. Place the level on the weighing surface if flat. If the weighing surface is not flat place the level on a surface that will display an indication of the balance being level. Indicate on the certificate that the balance is level.

6.1.7 Exercise the balance by applying weight close to the maximum range or placing the amount of force to obtain close to maximum range without exceeding max capacity.

6.1.8 If the balance has a platform or beam lock, lock the device before applying any weights. Unlock the balance for weight indication.

6.1.9 For digital balances press the zero or tare button. If balance is equipped with a lock, then set the lock to off, zero the load indicator, or balance the beam at no load. Verify that the indicator reads zero. Indicate on the certificate that the balance is zero with a mass of zero.

6.1.10 Ensure the weights are currently in calibration or standardization in accordance with Table 3 for General-Purpose Masses. Make sure weights are clean and utilize proper weight handling techniques.

6.1.11 Balances and masses indicating in the Avoirdupois system (pounds and ounces) will meet the same levels of accuracy as the value stated in SI units.

6.2 ACCURACY MEASUREMENT

6.2.1 Accuracy will be determined at a minimum of five different test loads. For single range balances include zero and as close to maximum capacity that weights will allow. The other test loads must be approximately 25, 50, and 75% of the maximum capacity. For balances with multiple ranges or beam-arms, verify each range or beam-arm, with test loads of approximately 10, 50, and 100% of the range capacity. The test load may be values presented by a minimum number of weights, not the exact value calculated from the capacity.

EXAMPLE: For a balance of 4,600 g capacity, the 25% and 50% loads would not be 1,150 g and 2,300 g. Use a single 1,000 g weight and minimum weights to make a 2,500 g load.

6.2.2 Record the nominal value of the weight in the nominal weight column of the certificate.

6.2.3 Apply test loads in order of increasing value.

6.2.4 For weighing devices with multiple ranges or beam-arms, verify each range and beam-arm, at a minimum, with test loads of approximately 10, 50, and 100% of the range or capacity.

6.2.5 Increasing from zero to maximum capacity, place the weights in the middle of the balance weighing pan. At each desired test load after the reading has stabilized, record the indication. Some digital balances have an indication that will display when the reading has stabilized. If the balance does not have a stabilization indicator, each load should be given no more than 30 sec. before taking the reading.

6.2.6 Remove the weights.

6.2.7 Verify that each of the indicated load are in tolerance of the accuracy requirements for the class of balance listed in Table 2. Report the weighing device as failing to meet the accuracy specifications if any range cannot meet the accuracy requirements for the class.

6.2.8 Verify beam-arm hanger weights individually. Use a beam-arm slider to determine the hanger weight's deviation. Report the weighing device as failing to meet the accuracy specifications if any range cannot meet the accuracy requirements for the class best describing that range. Report the weighing device as failing if it fails to operate properly (according to the manufacturer's instruction manual) on all ranges.

6.3 ECCENTRIC MEASURMENT

6.3.1 If the balance has a hanging pan or hopper, eccentric test is not required. Proceed to Section 6.28.

6.3.2 Select a single weight load approximately 30-50% of the balance capacity. If a single weight cannot be obtained, place one weight on top of the other or as close together as possible.

CAUTION – 1 Care must be taken when performing this test on balances with leveling pans to position weights so that they do not tip off the tilted pan surface.

6.3.3 Set the balance to zero. The balance can be set to zero each time the load is removed to prevent drift.

6.3.4 Place the weight in the center of the balance weighing pan. Record the indicated value from Position 1 (Figure 1) on the certificate.

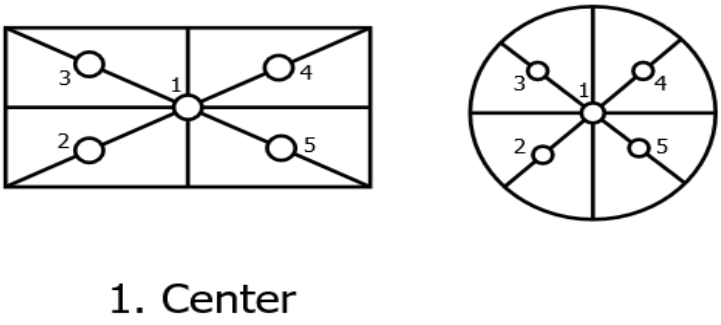

Figure 1. Eccentric Measurements

6.3.5 Move the load to the first off-center loading points (Position 2 in Figure 1). Note the indicated weight. Repeat for the remaining three off-center loading points.

6.3.6 Remove the weight.

6.3.7 Verify that the maximum difference between the indication of the different positions and the center position is in tolerance of the accuracy requirements for the class of balance listed in Table 2. Report the balance as failing if out of tolerance.

6.4 **REPEATABILITY MEASUREMENT**

6.4.1 Select a single weight load approximately 50-100% of the balance capacity. For multiple range balances, select a single weight between 50% and 100% of the balance capacity for each range.

6.4.2 Before each measurement, set the balance to zero.

6.4.3 Place the weight in the middle of the balance weighing pan. After the reading stabilizes record the indication.

6.4.4 Remove the weight.

6.4.5 Repeat this measurement four more times.

6.4.6 Verify that the difference between the highest and lowest values is not greater than twice the balance's readability. Report the balance as failing if the difference is greater than twice the balance's readability.

7. STANDARDIZATION LABEL

7.1 If the balance passes, place a standardization label on balances so the user can see it easily.

7.2 The label must contain the following:

- balance serial number,
- date performed,
- date due, and
- technician performing the standardization.

8. STANDARDIZATION CERTIFICATE

8.1 A standardization certificate must be issued for the balance to include the following information:

- title "Standardization Certificate,"
- manufacture: model number, serial number, and nomenclature,
- equipment Location,
- date performed, interval, next due date,
- whether the balance passed or failed the requirements for the stated class. If it fails, the cause of failure,
- balance class and capacity,
- check for level,
- nominal weights,
- indicated loads,
- deviation,
- masses model number, serial number, date last standardized or calibrated, and
- technician performing the procedure and date.

PART II – CALIBRATION OF BALANCES

9. PROCEDURE

9.1 Perform the calibration of balances in accordance with ASTM E898.

10. TABLE REFERENCES

Table 1—Classes of Analytical Balances

Class	Accuracy in grams	Sensitivity and Readability in grams (a)	Class of standard masses (b)
A	0.0002	0.0001	1,2,3
B	0.002	0.001	3
(a) Readability of digital readout or graduations on mechanical balances. (b) Suggested class of masses for calibrating balances IAW ASTM E617			

Table 2—Classes of General-Purpose Balances

Class	Readability and Sensitivity in grams	Accuracy in grams (a)
G1	0.01	0.02 or 0.1 %
G2	0.1	0.1 or 0.1 %
G5	1.0	1.0 or 0.1 %
G20	5.0	5.0 or 0.1 %
G100	20.0	20.0 or 0.1 %
(a) Accuracy equal to the mass stated or 0.1 % of the test load, whichever is greater, throughout the range of use.		

Table 3—Tolerance for General Purpose Masses

Nominal Denomination	Maintenance Tolerance(a)	Nominal Denomination	Maintenance Tolerance (a)
20 kg	1500 mg	30 g	30 mg
10 kg	1000 mg	20 g	20 mg
5 kg	800 mg	10 g	15 mg
3 kg	500 mg	5 g	10 mg
2 kg	400 mg	3 g	8 mg
1 kg	250 mg	2 g	6 mg
500 g	175 mg	1 g	4 mg
300 g	150 mg	500 mg	3.0 mg
200 g	100 mg	300 mg	2.0 mg
100 g	70 mg	200 mg	1.5 mg
50 g	40 mg	100 mg	
(a) Acceptance tolerances on new masses are one half of the maintenance tolerances.			